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ABSTRACT

Fifty-six Toronto (Ontario, Canada) seventh-grade and eighth-grade learning-disabled students whose handwriting was very difficult to read were randomly assigned to either an experimental or comparison group. Experimental group students were loaned a portable computer to use freely at school and at home during the course of the experiment. Computer-written and hand-written compositions done in time-controlled situations were collected 14 times over an 8-month period. These pieces were scored holistically and analytically. Data were also collected on experimental students' self-reported, parent-reported, and teacher-reported use of the computers. Results indicated that: (1) half of the experimental students made frequent use of the computers at home and at school, and (2) a majority of these frequent users (and far more of them than of either the infrequent users or the comparison subjects) made significant improvement in the quality and quantity of their written work. Differences in improvement in quality and quantity of writing between frequent users and others were statistically significant. No significant differences were, however, observed in surface features such as spelling and punctuation. Assessment tools used and 12 references are appended. (Author/JDD)

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Laptop Computers and The Learning Disabled Student

A Study of the Value of Portable Computers to the Writing Progress of Students With Fine Motor Problems

No. 193

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Lap Top Computers and The Learning Disabled Student

A Study of the Value of Portable Computers to the Writing Progress of Students with Fine Motor Problems

February 1990

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Abstract

An experiment was carried out in several schools in Toronto in the 1988-89 school year based on the idea that portable computers might be an effective aid to students who have poorer than average fine motor control and are thus disadvantaged in the physical act of writing.

Fifty-six Grade 7 and 8 students identified as learning disabled and whose handwriting was very difficult to read were randomly assigned to either an experimental or comparison group. Experimental group students were loaned a portable computer to use freely at school and at home during the course of the experiment. Computer-written and hand-written compositions done in time-controlled situations were collected 14 times over an eight month period. These pieces were scored holistically and analytically. Data were also collected on experimental students' self-reported, parent-reported, and teacher-reported use of the computers.

Results indicate that (1) half of the experimental students made frequent use of the computers at home and at school; and (2) a majority of these frequent users (and far more of them than of either the infrequent users or the comparison subjects) made significant improvement in the quality and quantity of their written work. Differences in improvement in quality and quantity of writing between frequent users and others were statistically significant. No significant differences were, however, observed in surface features such as spelling and punctuation.

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INTRODUCTION

Students of senior school age who have poorer than average fine motor control are disadvantaged in the physical act of writing. Such disadvantage is often related to lowered academic performance and self-concept as a learner. The disadvantage is felt in all written work. The idea that portable computers might be an effective aid to such students formed the basis for an experiment which was carried out in several schools in Toronto, in the 1988-89 school year, for a group of 56 Grade 7 and 8 learning disabled students.

In order to ensure that the students in this study could have full access to the tool and that they could use it for all their written work (not only story-writing), portable lap-top computers were used and were given to the experimental subjects for a period of seven months. During that time, these students were free to take the computer from class to class at school, and home with them evenings, weekends, and holidays. They used it as much or as little as they chose; the only required use was to produce between two and four stories per month, each one to be written in class in a fifteen minute period. A control (comparison) group was formed of students in the same classrooms, and assignment to computer or control group was random. The hypothesis that motivated this experiment was that students who have signficant difficulty with the physical act of writing, because of fine motor handicaps, would be motivated (by the capablility of the computer to facilitate production, editing, and attractive text) to produce longer, richer, more conceptually developed pieces of writing. The students chosen, and subsequently assigned to either computer or control group, were screened for reading ability (grade 4 or above) and for fine motor coordination (well below average). Their written compositions were collected and compared, in both quantitative and qualitative (holistic) analyses.

REVIEW OF THE LITERATURE

The literature on the usefulness of the computer as a tool to improve children's written work is less than a decade old. Nonetheless, almost from the beginning of that young tradition there has been an interest in the wordprocessing function as it may pertain to students with a variety of motor and learning handicaps. Mokros and Russell (1986) reported that 88% of the schools they surveyed in 1984-1985 were using microcomputers with learning or behaviourally disabled students. The basic idea is that if keyboarding is easier and more rewarding, then perhaps an improvement in ease and quality of production will have spillover effects on the willingness to compose and the quality of the thought and composition.

Research on both normal and special populations is promising, but not conclusive. Examining only studies of normal populations which employed control groups, we find the following:

Levin et al. (1983) report that a four month experiment in a Grade 3/4 class found a significant advantage for the computer over the paper and pencil group in both quantity (number of words per sample) and quality, measured holistically. (Positive correlations between quantity and quality are a repeated finding.) Quinsaat (1983, reported in Bobrow, 1985) reports similar findings for number of words ("fluency"). Quality measures were not included. Bobrow (1985) concludes from the literature that average children writing with a computer will write more and spend more time text-editing than will children using pencil and paper. Larter (1987) compared the written work of 30 computer-using with 30 non-computer-using students in each of grades 1, 3 and 6 over a six-month period. She concludes that "... elementary children, particularly those in the primary grades, write more and write better with microcomputers than they do with traditional tools." (p.82)

Studies of children with various kinds of learning handicaps are most typically done without control groups, with children's progress over time being used as an indicator of success. The implied but untested assumption is that less progress would be made

without the computer. An obvious population of interest is students whose ability or facility with pen and paper is limited.

For example,work done in a school for learning disabled students in Ontario (Lindsay and Marini, no date) described an overwhelmingly positive response to microcomputers by the students. While advantages were found on many kinds of activities, "the most effective use of the microcomputer as a tool has involved the word-processing programs.... These programs were used most effectively in the project in the teaching of creative writing .... Students who reportedly had never written a composition of any kind wrote their first stories using the microcomputer.... Students not only added to the length and quality of their compositions in terms of organization and content, but they also engaged in the writing process more frequently." (pp.10-11)

Similarly, the Mokros and Russell survey of special educators found that "several teachers indicated that they had seen an impressive increase in children's willingness to write.... While no teachers were ready to claim that word processing had yet influenced the quality of student writing, many expected to see writing improvement once students used the tool for a longer period of time. A few teachers had seen an increase in the quantity of writing." (1986, p.187)

Bobrow (1985) followed 12 subjects, ages 8 to 12, all identified as learning disabled, over a six-month period. No control group was used. The children used word processors twice a week. They exhibited a sizeable increase in fluency and in number of editing procedures, over the six-month period, as well as some tendency to generalize this greater facility to pencil and paper production.

A study of similar size and extent is reported by MacArthur and Graham (1987). They studied 11 learning disabled children in Grades 5 and 6. The study periods were four three-week sections, a total of twelve weeks spread over a school year. During each of these three-week sessions, children composed three stories, one per week. One story was handwritten, one was written on a wordprocessor, and one was dictated to the teachers. Contrasting the handwritten and wordprocessed stories, the authors report no significant differences in number of words; average t-unit length (a measure of syntactic complexity); grammatical error rate; or on either of two vocabulary measures. However, stories written on the computer did increase in length over time, while handwritten stories did not. Also, stories generally improved over time in quality and structure, although the handwritten stories improved as much as those computer-produced. Stories composed

on the computer took significantly longer to compose, at least in part because of typing speed (or, the lack thereof). In fact, word-processing, at 4.6 words per minute, was less than half as fast as handwriting. Comparisons of revisions by number and kind revealed different patterns between the two methods of production, but no clear advantage for either; most revision was of a relatively superficial nature, and made little difference to text quality. However, word-processing was definitely the method preferred by the students. They preferred it even to dictation, though they preferred the stories they dictated as finished products, giving as a reason their greater length. (The dicatated stories were in fact superior on measures of fluency and quality as well, but the students mentioned only length.) The researchers conclude that it is important to give students typing skills in order to facilitate use of the computer, and that using a computer does appear to be a motivating factor for children doing composition. The study neither proves nor disproves the hypothesis that computer use will improve writing quality.

Recently, Clavier et al. (1988) described a three- to six-month experiment with four physically disabled eleven to twelve year old children who used word processors. They did not include a control group. They report that both their wordprocessed and handwritten work improved in speed and legibility as a result of the experience using the computer. There was no change in students' self-concept, which was measured before and after. Two of the four children said they preferred handwriting.

Most recently, a small-scale study of four 11-12 year old LD students (Morton, Lindsay & Roche, 1989) included a matched, normal-achieving comparison group. Students in this study used the microcomputer for creative writing over a three-month period in a computer-lab setting for 30 minute sessions (number of sessions unspecified). They also used paper-and-pencil for a comparable three-month period. Results were similar for the LD and normal-achieving students: an increase in the number of drafts and an increase in overall output; but no change in the amount of revision involving either surface or meaning features. These results suggest that the LD students' use of and benefit from word-processors for creative writing is very similar to that of non-LD students, and is limited to quantitative, not qualitative, change.

The research to date is inconclusive in answering the question whether children who are diagnosed as learning disabled, and who exhibit significant fine motor handicaps, such that they produce written stories and essays with considerable difficulty and lack of enjoyment, will find composition easier and more satisfying using a wordprocessor, and

whether they will in fact come to produce both longer and qualitatively superior written products. Studies to date are very small scale, and notably lacking in comparison or control groups. The Morton et al. study, although it is unique in including a comparison group for learning disabled students, included only four students per group, and was of only three months duration. The most searching and thoughtful of the studies cited above (MacArthur and Graham, 1987) used subjects as their own controls in three composition conditions, including handwriting and wordprocessing, and found no significant advantage for the latter, except a motivational one. However, that study, while it spread over a school year, involved only three handwritten and three wordprocessed compositions; each story was written over two sessions, for a total of six handwriting and six wordprocessing sessions for the duration of the study. Although MacArthur and Graham's subjects had used computers over the preceding year and a half, the authors describe their subjects' keyboarding and editing skills as extremely basic. Thus, it would appear to make sense to examine the effects of handwriting versus wordprocessing experience on the quality of children's writing over a longer period of time, allowing for considerably more practice in both modes, to permit comparison of a more extensive and more cumulative data set. Portable computers, which students could use as much as they wish at school and at home would significantly extend the potential exposure time, in effect making a study of several months equivalent to one of much longer duration, where use is confined to a classroom. Such an experiment, if it includes a control group, can address the question whether improvement is clearly related to computer use, as the MacArthur and Graham study cannot. The study conducted in Toronto schools in 1988-89, and described in the following pages, is designed to address this question.

METHODOLOGY

Subjects

Fifty-six seventh and eighth grade students - 28 experimental and 28 control - from 11 Toronto elementary schools participated in the study. These students had three common characteristics: (i) they were all identified as learning disabled students - some attending resource rooms for a certain period each day, and others in learning centres full time; (ii) all had fine motor control problems as indicated by their virtually illegible penmanship; and (iii) all had attained at least the grade 4 reading level, according to their teachers. The reason for the last criterion was to exclude those with serious language problems and to examine only those who had fine motor problems.

Sampling Procedures

During the summer of 1988, two Board special education consultants identified a group of special education teachers who would likely be interested in the project. These teachers were from twelve schools - three in each of the four administrative areas of the City of Toronto Board of Education. They were invited to attend an orientation meeting in mid-September. The intent was to familiarize them with the objective of the project and to solicit their participation. Altogether 14 teachers showed interest in the study. They were provided with a kit containing screening instruments for selecting eligible students.

In late September, the 14 teachers administered the screening exercise by having their students write down three passages - one from dictation, one copied from the blackboard, and the other copied from a typed sheet. Two research assistants rated the legibility of the written passages. The students whose handwriting was most illegible were selected. The teachers were then asked to identify these selected students' reading level. Those with grade 4 reading ability or above were chosen. Altogether 56 students were found to be eligible, most of whom were boys (47 boys versus 9 girls). The number of eligible students for each teacher varied from two to ten. All eligible students for each of the 14 teachers were then randomly divided into two groups - the

experimental and the control. Each teacher had at least one experimental and one control student. Among the 28 experimental subjects, 24 were boys and four were girls.

Setting

Between October 1988 and May 1989, each of the 28 experimental students was loaned a Toshiba T1000 laptop computer along with a typing program (Mavis) and a word processing program (EasyWriter).[1] They were allowed to take the computer from class to class at school and to use it at home. In addition, each school was given a printer for these students to print their work.

Two research assistants were sent to each school in September and early October to offer the experimental students a small-group training session in basic computer and word processing skills. The students were then encouraged to use the typing program provided to practise their keyboarding skills. In November, the students started to use the word processing program for their writing. In late November, a researcher visited most of the schools to ensure that the students were using the word processor properly and to offer further assistance when needed. In addition, at the request of some participating teachers, two special meetings were called in November and January respectively. Although not all of the participating teachers and students attended the two meetings, those who showed up were enthusiastic, sharing among themselves the technical problems they encountered and their knowledge of the word processing program.

It should be noted that although training and support were offered by the research team, conscious efforts were made to avoid the teachers and students from being too dependent on outside assistance. It was the attempt of the study to see how effective the laptop computers could be when learning disabled students and their teachers worked together in a more-or-less natural classroom setting.

As far as the control students were concerned, they were asked to write their stories with paper and pen as usual; but they were allowed to have exclusive use of the laptop computers upon the conclusion of the experiment, during the month of June.

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1. Prior to the experiment, two laptop models were tested with two Grade 7 students. Based on the test results, the Toshiba model was selected. As for the two software programs, the basis for adopting them was their availability at the Board at the time the experiment was planned. Some elementary schools had used the two software packages for their regular school programs, and no negative feedback had been received.

Data Collection and Methods of Analyses

Altogether five different sources of data were used for analyses. They were: (1) measures of students' academic self-concept and of attitude to school, based on Boersma and Chapman's "Student's Perception of Ability Scale" (see Appendix A); (2) frequency of computer use by the experimental students as recorded in their self-reported log forms; (3) interview data from both the experimental and the control students, their teachers and their parents; (4) 14 writing samples gathered from both the experimental and the control students over a period of eight months; and (5) anecdotal notes based on researchers' observations of and interactions with the participants.

(1) Student's Self Perception Scale

Boersma and Chapman's "Student's Perception of Ability Scale" (1977) was used to measure students' academic self-concept and of attitude to school. Six indicators are included in the scale: general ability, arithmetic ability, school satisfaction, reading/spelling ability, penmanship and neatness, and confidence. The instrument was administered twice by special education consultants - in early October as a baseline measure, and in May as a post-intervention measure. The purpose was to see if students' self-perception and attitude toward school would change as a result of the intervention.

(2) Log Forms

Throughout the intervention period, the experimental students were expected to record their daily use of computers in the log forms provided. Their teachers collected the log forms every two weeks and returned them to the researchers.

(3) Interview Schedules and Content

Telephone interviews were conducted periodically by the two research assistants with all subjects, their teachers and their parents. The interview schedules and contents were as follows:

- Experimental students: They were interviewed five times between December 1988 and June 1989 concerning their computer use and their general attitude towards story writing and school.

- Control students: They were interviewed once, in March. Fewer questions were asked, and the only questions that were common to them and to the experimental group were those related to their school and writing attitudes, and their preference of writing medium. However, these students were also questioned about their computer use, if any.

- Participating teachers: The 14 teachers were interviewed five times regarding their experimental students and twice about their control students. In both cases, the teachers were asked about their students' school attitudes, academic work and story writing; but in the case of the experimental students, two additional questions were asked pertaining to their computer use.

- Parents: Parents of the experimental subjects were interviewed five times, while those of the control were interviewed once. Again in both cases, the parents were asked about their children's school attitude, academic work, and story writing. Parents of the experimental students were further questioned about their children's computer use at home.

The data gathered from these interviews serve two purposes: (i) to examine whether teachers' and parents' perceptions of the students' work changed over time as a result of the intervention; and (ii) to provide additional information on subjects' computer use and their overall performance.

(4) Writing Samples

Both the experimental and the control subjects were expected to submit 14 writing samples from October through May. The time allowed for producing each writing sample was 15 minutes during the regular class period. For the first four writing samples in October, the topics were prescribed: "The first day of school", "A trip to McDonalds", "Stranded on a desert island", and "A birthday". Both the experimental and the control subjects were asked to use paper and pen for producing these four stories, which would form a baseline for subsequent analysis. In the meantime, most of the experimental students were practising their keyboarding skills with the use of the Mavis program. In November, the experimental students began to produce their stories on computers. In the six months between November and April, six writing samples were collected - computer generated ones from the experimental students, and handwritten ones from the control students. Both groups were allowed to choose their own topics. In May,

story collection occurred weekly; for the last two writing samples, the titles were again assigned: "If I were the principal of this school", and "My trip to Mars".

All writing samples gathered from both the experimental and the control groups were evaluated by two methods - holistic scoring, and analytic scoring. It should be noted that during the course of the study, several problems occurred which led to a reduction of the number of subjects whose writing samples were analysed. For instance, a few students withdrew from the project; a few teachers failed to collect their student data on a regular basis; and an experimental student had his computer vandalized and had no access to the machine for months. As a result, the number of experimental subjects whose stories were analysed was 19 instead of 28, and the number of control subjects whose writing samples were available was also 19 instead of 28.

Holistic Scoring

The purpose of holistic scoring is to rate the overall text quality of each writing sample. After all story samples were gathered in June, two elementary school teachers trained and experienced in holistic marking were hired to be the scorers. Both teachers were unfamiliar with the purpose and design of the study prior to or during their scoring. To reduce the effect of poor handwriting or typos on scorers' rating, all the students' writing samples (both handwritten and computer generated ones) were typed by secretaries. Surface errors in spelling, capitalization and punctuation were also corrected in the typed version, while the content and the sentence structure remained intact. The purpose was to allow the two scorers to concentrate on the overall content. Furthermore, all identifying information, such as student name and the date of composition, was removed and a code was assigned instead. The story samples were then randomly ordered for the scorers.

The scorers developed a scale of 1 to 7 for rating the students' writing. (See Appendix B.) Each scorer received a complete set of randomly ordered stories. The rating of the two teachers was done independently. For each writing sample, the scores they assigned were then averaged. In 80 percent of the writing samples, the two teachers had total agreement in their scores. In cases where discrepancies occurred, the difference in scores was at only 1 scale point. To determine the inter-rater reliability, Pearson product moment reliability coefficient between the scores assigned by the two teachers were calculated; the reliability coefficient was .94.

Analytic Scoring

Two research assistants were trained in a text analysis method developed by one of the authors. (See Bryson and Siegel's paper, 1989, for details.) The purpose was to use a quantitative method to assess the structural aspects, such as surface features, syntax, and language complexity, of the students' writing. Several measures were used:

- number of t-units,
- mean number of words per t-unit,
- number of causal statements,
- number of pronouns with unclear or unnamed antecedents,
- number of syntactic errors,
- number of spelling errors, and
- number of punctuation errors.

A t-unit, according to Bond (1975), is a single independent clause (i.e., both subject and verb are contained) together with any subordinate clauses which are grammatically related to it.

(5) Anecdotal Notes

During the course of the study, the research assistants and researchers had made several formal and informal contacts with the subjects, the teachers and the parents. Anecdotal notes based on their interactions with and observations of the participants were recorded. This information supplements the four types of data mentioned above.

RESULTS

Frequency and Types of Computer Use

Since the experimental subjects were allowed to use their laptops as much or as little as they chose, it was found that the frequency and types of usage varied from student to student. According to the information gathered from the students' self-reported log forms and the series of interviews, among the 28 experimental students, nine (32%) used their computers a lot (almost every school day per week during most part of the study); five (18%) a fair amount (several times a week); ten (36%) to a very limited extent (about once or less a week); and the other four subjects (14%) withdrew in the middle of the project. For the following analysis, we shall define those 14 subjects who used their computers a lot or a fair amount as "computer users", and the other 14 who used them infrequently or dropped out as "non-users".

The interview data indicate that, at school, the users used their laptops for both story-writing and other school work (e.g. note-taking, report-writing, projects, journals), while most non-users used their computers for producing writing samples only. It was also found that most users brought their computers home for their school work (except for the last two months of the experiment), whereas very few of the non-users ever took their laptops back and forth between school and home.

Interestingly, in all interviews both the computer users and non-users (except for two non-users) said that they liked their laptop computers in all interviews. However, the two groups differed significantly in their degree of enthusiasm. Virtually all the users claimed that they liked their laptops "a lot" during all five interviews, while most non-users reported "somewhat" especially in the middle and latter parts of the study period.

The relatively lower frequency of computer use and enthusiasm among the non-users did not seem to be related to such technical problems as loading or accessing a program, saving or retrieving their work, or printing. Indeed, the student and teacher interviews indicated that a higher percentage of the computer users had encountered those technical problems than the non-users. According to the teachers, some students failed

Period III from March to early May 1989, when another four stories were gathered from both groups of subjects.

Period IV from mid-May to late May 1989, in which the last two writing samples, with prescribed topics, were collected from each group.

Overall Quality

The mean scores on the holistic scoring system, a measure of overall quality of writing, are shown in Figure 1.

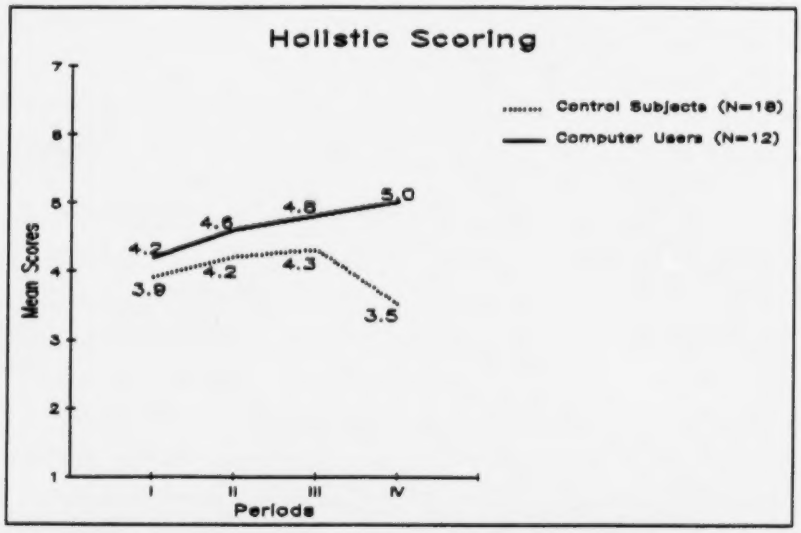

Figure 1: Progress in the Overall Quality of Writing

As a whole, the computer users showed a steady rate of progress over the four time periods, whereas the control group did not show any significant improvement.[2] The data indicate that the groups were not different at the beginning of the school year but by the end of the year the productions of the learning disabled children had improved in overall quality as a function of learning to use and having access to a microcomputer.

A further examination of individual students' holistic scores indicates that among the computer users, seven (nearly 60%) out of 12 (for whom we had a sufficient number of

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2. A repeated measures ANOVA on these data indicated significant effects of treatment ($F(1,28) = 7.96$, $p < .01$), time ($F(3,84) = 4.61$, $p < .005$) and a significant Time x Treatment interaction ($F(3,84) = 6.00$, $p < .001$). Individual comparisons (t-tests) yielded significant differences between the computer and control groups at Periods II and IV but not at Periods I and III.

to use the laptops for other reasons. For instance, it was found that a number of non-users as well as those who withdrew from the experiment were not too comfortable with computers. Their teachers reported that they were either slow at acquiring or not motivated to acquire the basic computer and keyboarding skills. These students found it more agonizing to write with computers than with paper and pen. Some of these non-users mentioned at least once during the five interviews that they preferred to write their stories with paper and pen, with which they felt more comfortable, and which they found faster and easier to use than computers. There were, however, a few non-users who were comfortable with computer but did not use it frequently for other reasons. For example, there was one student who made a deliberate effort not to rely too much on the computer for his writing. There were a few who were so preoccupied with other work, interests or problems that they did not spend too much time on their laptops.

With this in mind, let us compare the writing results of the computer users with those of the control group. It should be noted that the writing results of the non-users will not be considered in the following analysis for two reasons. First, since the purpose of this study is to examine the effect of computer use on students with handwriting problems, it will only confound the findings if non-users' writing results are included as part of the experimental group for comparison. Second, because half of the non-users failed to submit their writing samples on a regular basis, it is difficult to generalize the overall writing results for this group.

Writing Results

In order to gauge the subjects' writing progress over time, the 14 writing samples gathered between October 1988 and May 1989 were analysed for four time periods.

Period I — pre-intervention stage in October 1988, when the experimental and the control students alike had to produce four handwritten stories with prescribed titles.

Period II — from November 1988 (when the intervention began) to February 1989, during which four computer-generated stories on topics of their own choice were collected from the experimental students, and four handwritten ones from the control subjects.

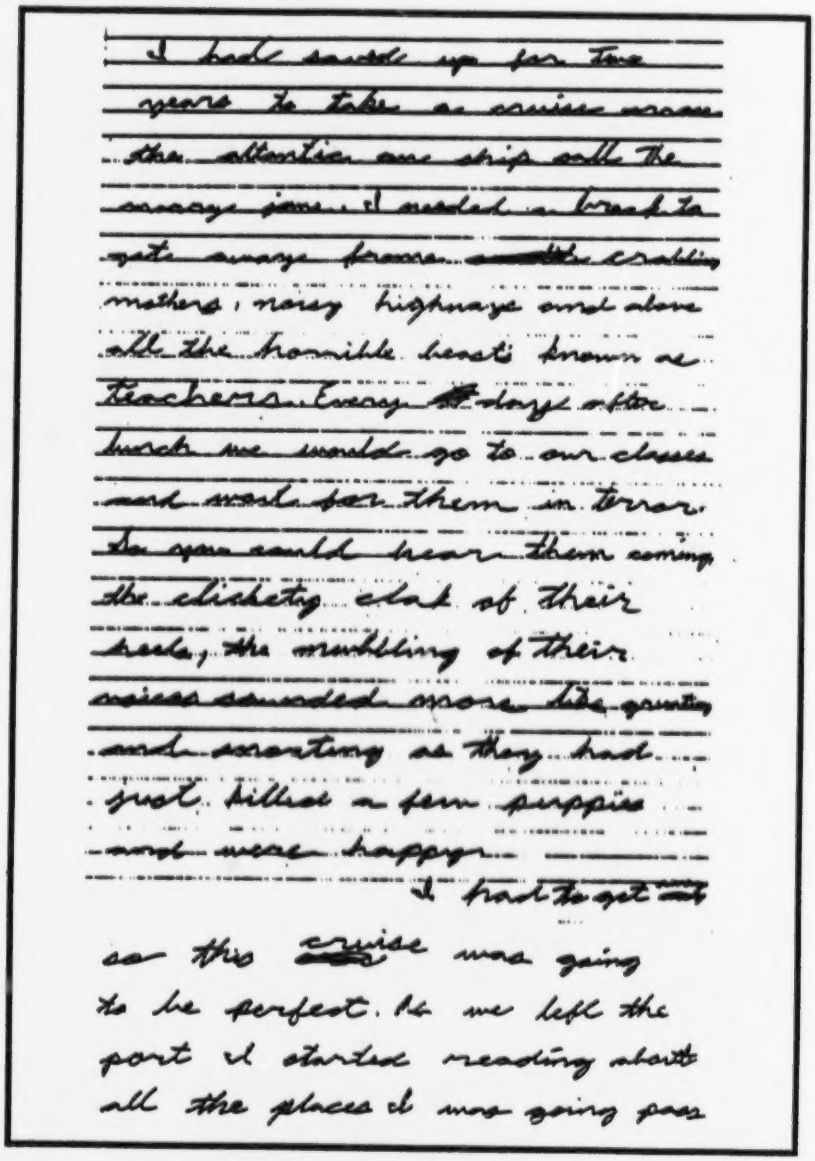
well here I am again and I am suposed to write somthing about a trip to Marrs. Now being that no one has ever been to Marrs I supppose that it could be anything you want, So I would prefer to imagine a world totaly unlike ours. Now when I was there last it was the 2oth moth so the sky was purple and all the little Woopnackers were begining to hatch. Whoopnackers are small slime covered mamals found only in Lithuwainia. Well the waether was very nice by Marrsainian stadards but I had to stay in my hole durring acid storms other wise my skinwould burn off and I would be left to die an aganizing death and I just didn't feel up to that. I spent most of my time ridding the flimwhappers at their abusement park but I almost lost an eyebrow in the Soosamasnatcher. The food there was good but it to was different, you had to suck it through a straw up your nose, not an easy task but at least you didnt have to tast it exept for the chuks that some times got caught half way up, now that was rough.
All in all it was a good trip I plan to go back soon

Period IV "My Trip to Mars"

(Holistic Score: 7)

writing samples) showed a progressive increase in their scores over the four time periods. For the control group, however, only five of the 18 subjects (less than 30%) showed some progress in scores over time. Figures 2 and 3 illustrate samples of writing produced by a computer user and a control student on two prescribed topics in the first and the last periods of the experiment.

Figure 2: Two Writing Samples of an Experimental Student



I had saved up for two years to take a cruise across the Atlantic ane ship calle The ocean liner. I needed a break to get away from the crabbing mothers, noisy highways and above all the horrible beasts known as teachers. Every day after lunch we would go to our classes and would fear them in terror. So you could hear them coming the clicketing clack of their heels, the mumbling of their voices sounded more like grunting and screaming as they had just killed a few puppies and were happy. I had to get out as this cruise was going to be perfect. As we left the port I started reading about all the places I was going pass

Period I: "Stranded on a Desert Island"
(Holistic Score: 4)

Structural Aspects

T-units

The number of t-units is used to measure the quantity of writing in terms of the number of meaningful clauses produced in the writing samples. The mean number of t-units for the computer and control groups at each of the four time periods are shown in Figure 4.

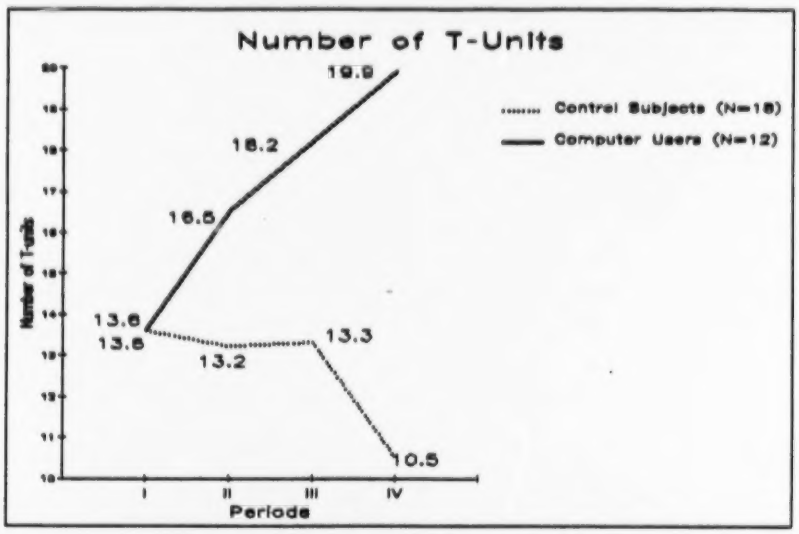


Figure 4: Progress in the Quantity of Writing

The computer and the control groups were not different initially in terms of the length of the stories that they wrote but they did differ by the end of the year.[3] The computer group wrote longer stories after exposure to the microcomputer. Therefore, there were significant increases in the quantity of output as a function of computer usage. It should, however, be noted that the mean length of t-units for all the groups at each time period did not change significantly over the course of the study.

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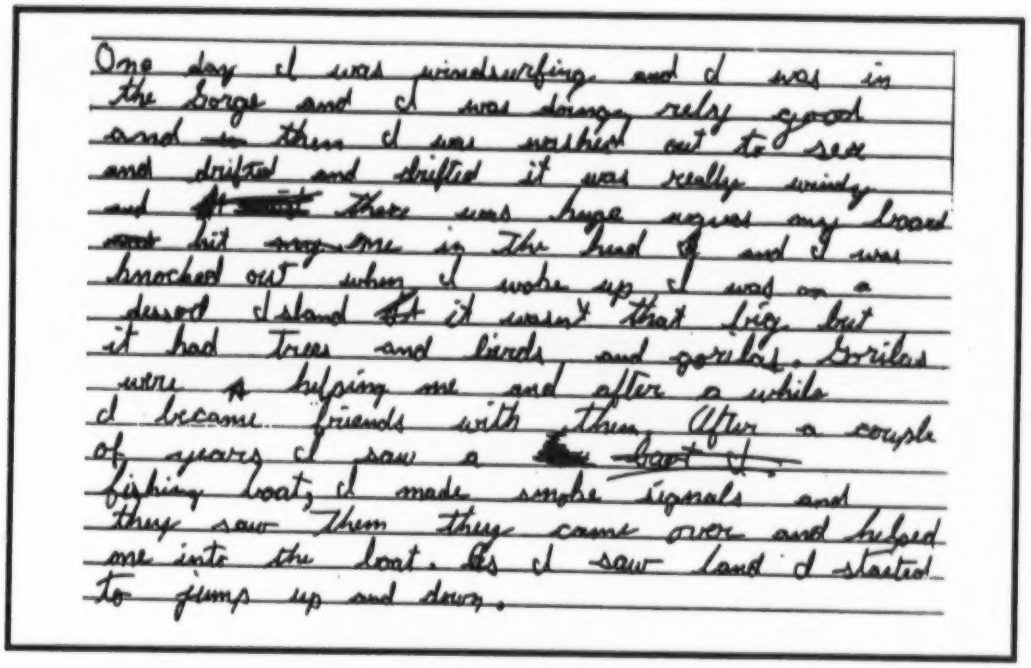
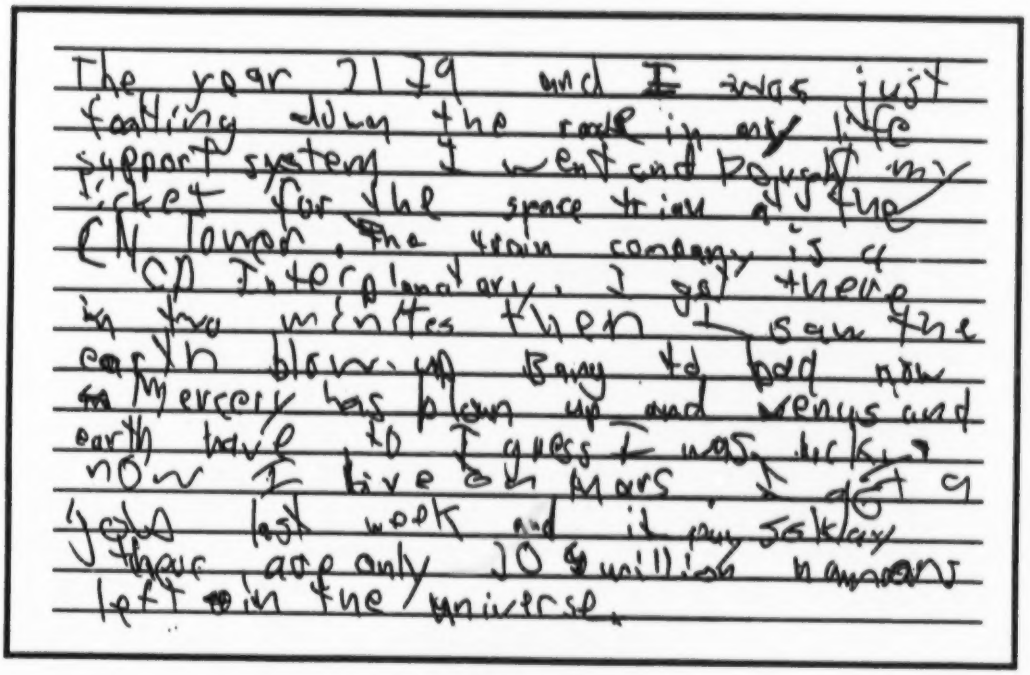
3. A repeated measures ANOVA indicated significant effects of Treatment ($F(1,29) = 7.59$, $p < .01$), and a significant Time x Treatment interaction ($F(3,87) = 6.55$, $p < .001$). There were significant differences between the control and computer groups at Periods III and IV but not at Periods I and II.

Figure 3: Two Writing Samples of a Control Student



One day I was windsurfing and I was in the surge and I was doing really good and then I was washed out to sea and drifted and drifted it was really windy and there was huge waves my board hit me in the head and I was knocked out when I woke up I was on a dessert island it wasn't that big but it had trees and birds and gorilas. Gorilas were helping me and after a while I became friends with them After a couple of years I saw a boat. fishing boats I made smoke signals and they saw them they came over and helped me into the boat. As I saw land I started to jump up and down.

Period I: "Stranded on a Desert Island"
(Holistic Score: 4)



The year 2179 and I was just feeling duty the rock in my life support system I went and bought my ticket for the space train at the CN Tower. The train company is CN Interplanetary. I got there in two minutes then I saw the earth blow up Boy to bad now Mercery has blown up and venus and earth have to I guess I was lucky now I live on Mars. I got a job last week and it pay 50 k/yr There are only 10 million humans left in the universe.

Period IV "My Trip to Mars"
(Holistic Score: 3)

Causal Statements

Causal statements involve the correct use of conjunctions and propositional statements. They indicate one's ability to make connections between events. The number of causal statements is thus used as a measure of the students' writing quality. The number of causal statements for the computer and the control groups at each time period are shown in Figure 5.

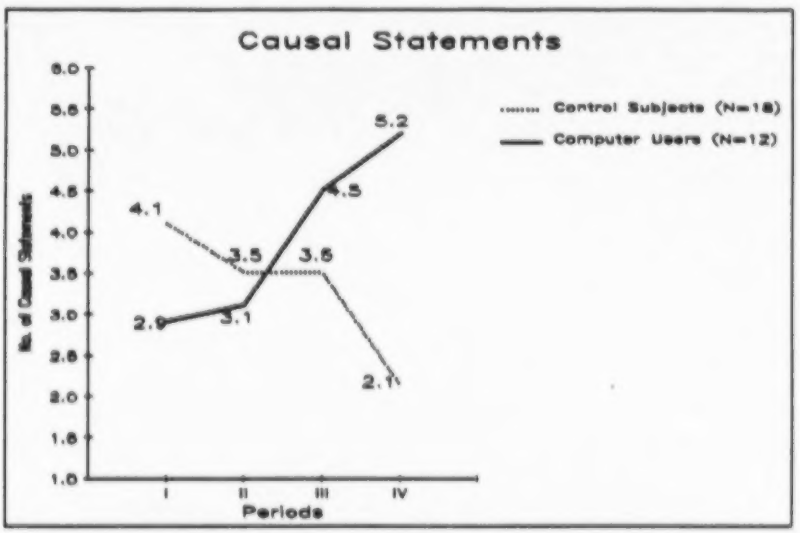


Figure 5: Progress in the Number of Causal Statements

Interestingly, in the early periods, the control group had a higher mean number of causal statements than the computer group; however, the reverse was true by the latter periods.[4] That is, the computer group was using more causal relationships in their writing by the end of the school year.

Grammatical and Surface Features

Although the mean number of syntactic errors per t-unit[5] and the number of unclear pronoun referents[6] declined significantly with time, there was no differential change in

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4. An ANOVA conducted on these data indeed indicated a significant Treatment x Time interaction ($F(3,87) = 8.43$, $p < .0001$). Individual comparisons indicated that the groups differed at Period IV but not at any of the other time periods.

5. An ANOVA indicated significant effects of time ($F(3,87 = 5.25$, $p < .002$)

6. An ANOVA indicated significant effects of time ($F(3,87) = 5.25$, $p < .003$)

the two groups. In addition, there were no significant changes in the number of spelling or punctuation errors per t-unit. These data indicate that there were no differences between the groups in the surface features of the stories.

Changes in Perceptions Over Time

A comparison of the subjects' pre- and post-scores on the "Student's Perception of Ability Scale" reveals that in neither pre- nor post-treatment period were there any significant differences among the computer users, the non-users, and the control subjects in terms of their self-perception and attitude towards school. Of the six measures in the scale (see p.8), the only area that indicates a significant positive change over time was confidence; and the change occurred in all three groups.

An examination of the teacher interview data also reveals no signficant change across the time periods in teachers' perceptions of computer students' overall performance, writing, academic self-concept and attitude to school. In addition, there was no significant difference in their perceptions of the computer or the control group. Similarly, when the parents of the computer group were compared with the parents of the control group in terms of their perceptions of their child's attitude to school and homework, there were no significant differences.

Despite the lack of overall significant differences in perceptions, there were success stories reported by individual students, teachers and parents. For instance, a parent gave this remark in her last interview: "[I'm] very happy with X's change since he started using the computer. X's self-esteem has improved tremendously. He now expresses himself instead of withdrawing, and loves writing." Student X himself reported that with the computer, he could get a lot more work done, and writing tasks became easier and more interesting.

The research assistants, who had considerable contact with the students, teachers and parents, reported several interesting cases. Below are two of the cases.

Case One:

> At the beginning of the project, Y was described by his teacher as distracted and unfocussed. He had reached a plateau in his work, which she characterized as unsatisfactory. In the last interview in May she reported that he was "much more concentrated and focussed -- more interested in putting things together", and he was often finishing his work on time. The computer appeared to play a major part in this turn-around:

early in the year, Y began doing everything but math on the computer, and his self-confidence seemed to increase as his competence with the computer increased. The teacher believed that the computer began very early to make a difference: "[Y] lives in a very small room -- and the computer has just begun to crack open the door." By May she said that "the computer has became a vital piece of equipment", and asked for special permission for Y to keep the computer for the last month: "It would make a tremendous difference to him!"

The student himself made this comment: "It doesn't take as much time; it's a lot easier to do stuff -- a lot more fun. Everything's organized: you can pull up a file instead of going through a messy binder." He preferred it to writing by hand: "You can read it a lot better, 'cause my writing's kind of messy."

Y's father, who also recognized how important the computer had become in his son's schooling, said, "Quite frankly, the only hope for his future education is in using a computer. My only hope, too, for getting him going." The father realized that Y's enjoyment of the computer and competence in using it to do his work had led him to become more confident than he was before.

Case Two:

Initially, a teacher reported that Z was discouraged about the computer after experiencing many problems with printer and program disks. The student decided that the computer was keeping him from his work -- it was an "add-on" rather than a tool to help him improve the quality of his other work.

However, after these initial problems were resolved, the student's attitude towards the computer changed. He reported at every interview that he liked it a lot, that he used it at home and at school several times a week, and that the reason he liked it was that it rendered his work more legible than his handwriting for his teacher to read.

His teacher said several times in the course of the year that she believed the computer had contributed both to an improvement in his attitude (he seemed happier and more confident in class, and was handing his assignments in on time), and to her own perception of the student's capabilities. In her words, the computer "has enabled me to point out some of Z's strengths in various reports -- he's very capable and interested in the computer... It's been an eye-opener to show us he's got 'hidden strengths!'".

DISCUSSION

Laptop Computers versus Desktop Computers

One of the unique features of this study is the use of laptop computers as opposed to the conventional desktop computers. One may question if similar results would occur if standard computers were used. Basically, the word processing functions of both configurations are similar to each other. However, in this particular experiment, it was found that the laptops had two advantages over the existing desktops in our sample classrooms. The two advantages were full accessibility and portability.

Full accessibility:

Although the control subjects were not supposed to use the laptop computers, they did, according to interviews, have access to other computers at school for story writing. However, their use was sporadic and restricted as they had to share among other students the limited number of desktop computers available in their classrooms. On the other hand, the experimental students had full access to their laptops. With full accessibility, these students had a greater chance of benefiting from the facilities offered by the computers for their writing.

Portability:

In addition, the laptops had the advantage of being portable, a feature which allowed the computer users to increase the use not only in terms of frequency but also in the types of usage. As discussed earlier, motivated users carried their laptops around at school for other classes, for example taking notes in science class. They also brought their computers home for school work, such as writing journals and preparing project reports. Indeed, based on the data gathered from the parent interviews, it was found that users who usually brought their computers home tended to spend more time in doing homework than the non-users or the control subjects.

It should, however, be noted that although the computers were portable, many students, including some regular users, found the unit heavy and fragile. And some students were reluctant to take their computers back and forth between home and school because of

the additional care and responsibility. A research assistant also reported that one student did not like to carry the computer around because of the fear of being labelled as a special education student.

In any event, the accessibility and portability features of the laptops allowed motivated students to increase their frequency of use and to extend their usage beyond story writing.

Some Students Might Need More Support than Others

Despite the greater accessibility offered by the laptops, it should, however, be noted that not all students who were given the computers actually used them. As mentioned earlier, among the 28 experimental subjects, half used their computers on a more-or-less regular basis for the duration of the study, but the other half used them to a very limited extent, including a few who dropped out of the study entirely.

Based on the interview data and anecdoctal notes, it was found that of the 14 non-users in the experimental group, six did not have difficulty in word processing, and indeed they liked their laptops. They failed to use their computers consistently or continuously for other reasons - for example, relocation to other school, family and health problems, preoccupation with other activities, a parent's request for withdrawal, and a student's choice of not relying too much on computers. There were, however, eight subjects who had very low keyboarding and word processing skills even by the end of the experiment. They were reluctant to use their computers despite their initial enthusiasm, and reported being more comfortable with pen and paper than with computers. An examination of their data reveals that these students had more fundamental learning problems than weak fine motor control. For instance, three of the students were motivated at least initially and had made efforts to acquire the necessary skills; but their progress was very slow and they had problems retaining information. Four other students were not motivated at all and, according to their teachers, they had behavioural problems. There was another student who was so preoccupied with his other school work and activities that he failed to acquire and practise the word processing skills. His initial enthusiasm soon turned to frustration and agony when asked to use the computer.

While all experimental subjects were offered one small-group training session in basic computer and keyboarding skills, the above findings indicate that for some students, especially those with more severe learning and behavioural problems, more

individualized training and more extensive support for a longer period of time may be needed in order to ensure their acquisition of necessary skills and to boost their motivation and success rate.

Effects on Writing

For students who used their laptops on a regular basis, the data indicate that the quantity and quality of their writing improved, whether quality is measured holistically or analytically. There were, however, no improvements in the surface features. The reason for this pattern of results may be a reflection of the fact that this learning disability is a problem with fine-motor coordination, among other difficulties. The computer can provide an alternative means for the fine motor coordination, and, therefore, can remove an obstacle to students' ability to think as they write, and to the fluency and quantity of their production. Spelling and punctuation are probably a result of problems with working memory, and the computer cannot correct these problems. The computer appears to be helpful with the production of good quality written work and the important dimensions of writing. The surface features such as spelling and punctuation require other remedial techniques or more sophisticated word processing packages.

Furthermore, one hypothesis that receives some support from a recent study of high school students is that one year may be too short a period of time for obtaining a full picture of the potential of computers to change students' writing and thinking. Tierney (1989) followed students at a high school in Ohio who were in a special program for two years in which they had half day long access all year to computers in their combined English/Social Studies class, for writing and writing-related activities, as well as a computer at home for their personal use.

Methods of evaluation were principally observational (written and video-recorded) with some interview data as well. The study found positive changes in both year one and year two. At the end of year one, students showed some development of thinking strategies, as well as increased self-confidence. Revision, however, was limited to additions and corrections, with little evidence of reorganization and refinement of ideas. These more significant kinds of improvement did occur in the second year of the study. In part this was related to students' use of more sophisticated, multilayered text packages, such as HyperCard; as well as to much greater facility with the hardware and software than they had after only one year. The study suggests that it may take two years of computer use,

at home and at school, before students become completely adept, so that the technology is completely at their service as thinkers and writers.

CONCLUSIONS

Overall, this project showed laptop computers to be helpful to half of the experimental group: writing disabled students who had handwriting problems which interfered with their schoolwork. The quality and quantity of their writing improved when they used the laptop computer on a regular basis. The study demonstrates that laptop computers are potentially very useful for improving the quality and quantity of writing done by writing disabled students, but that we need to integrate their use into the classroom with more support systems, especially for those students whose motivation or skills will otherwise prevent them from using the tool.

POSTSCRIPT

In late September and early October 1989, a follow-up telephone interview was conducted with the 14 participating teachers on how the laptops given to their schools were used after the experiment. It was found that the majority of the teachers used the laptops as additional workstations in their classrooms. That is, their laptops were made available for collective use in their classrooms, and were seldom moved from place to place, except for two of the classrooms in which some students took the computers to other classes and home. In two of the schools, the laptops were also sometimes used by the teachers for staff training or lesson preparation, for example taking computers home for practice and use. While most of the teachers treated the laptops as additional classroom resources, three other teachers continued to assign their laptops to specific students - one of the students was a former experimental subject, another student was a former control subject, and the other three students were new to the laptops. They were all allowed to use their laptops in other classes or at home, though the new student users were less likely to do so than the two subject students who were more familiar with the computers.

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Appendix A

Boersma and Chapman's "Student's Perception of Ability Scale"

DIRECTIONS

This booklet has a list of statements about how you feel about school. Some of these are true and some are not. Circle the YES if the statement is usually true of you. Circle the NO if the statement is not usually true of you. Read each question carefully and answer every item, even if it is hard to decide which answer is most like you. Do not circle both YES and NO. Just circle one answer for each statement. This is not a test so there are no right or wrong answers. Please mark exactly how you really feel inside about school.

1. I always understand everything I read	YES (NO)
2. My school work is usually untidy	(YES) NO
3. All new words are easy for me to spell	YES (NO)
4. I find it hard to understand what I have to do	YES (NO)
5. I think my school work is really good	YES (NO)
6. I usually have problems understanding what I read	YES (NO)
7. I am one of the smartest kids in the class	YES (NO)
8. I have neat printing	YES (NO)
9. I usually finish my schoolwork	(YES) NO
10. I am unhappy with how I read	YES (NO)
11. I like reading	(YES) NO
12. My printing is perfect	YES (NO)
13. I am good at spelling	(YES) NO
14. I make many mistakes in school	(YES) NO
15. I have problems in spelling	YES (NO)
16. I like to read to my parents	YES (NO)
17. I am happy with the way I spell	(YES) NO
18. I like making up endings to stories	(YES) NO
19. My teacher thinks I write poor stories	(YES) NO
20. I am poor at subtraction	YES (NO)

DIRECTIONS

This booklet has a list of statements about how you feel about school. Some of these are true and some are not. Circle the YES if the statement is usually true of you. Circle the NO if the statement is not usually true of you. Read each question carefully and answer every item, even if it is hard to decide which answer is most like you. Do not circle both YES and NO. Just circle one answer for each statement. This is not a test so there are no right or wrong answers. Please mark exactly how you really feel inside about school.

1. I always understand everything I read	YES (NO)
2. My school work is usually untidy	(YES) NO
3. All new words are easy for me to spell	YES (NO)
4. I find it hard to understand what I have to do	YES (NO)
5. I think my school work is really good	YES (NO)
6. I usually have problems understanding what I read	YES (NO)
7. I am one of the smartest kids in the class	YES (NO)
8. I have neat printing	YES (NO)
9. I usually finish my schoolwork	(YES) NO
10. I am unhappy with how I read	YES (NO)
11. I like reading	(YES) NO
12. My printing is perfect	YES (NO)
13. I am good at spelling	(YES) NO
14. I make many mistakes in school	(YES) NO
15. I have problems in spelling	YES (NO)
16. I like to read to my parents	YES (NO)
17. I am happy with the way I spell	(YES) NO
18. I like making up endings to stories	(YES) NO
19. My teacher thinks I write poor stories	(YES) NO
20. I am poor at subtraction	YES (NO)

21. I like to answer questions	YES (NO)
22. Working with my hands is hard	YES (NO)
23. I like doing printing	(YES) NO
24. I have trouble drawing pictures	YES (NO)
25. I am poor at silent reading	YES (NO)
26. I have problems printing neatly	YES (NO)
27. I am good with my times tables	YES (NO)
28. I am good at drawing	(YES) NO
29. When school gets tough I give up	YES (NO)
30. I like to do story problems	(YES) NO
31. My friends read better than I do	YES (NO)
32. I am good at printing	(YES) NO
33. I always do neat work	YES (NO)
34. I have difficulty getting my arithmetic finished on time	(YES) NO
35. I have difficulty working with numbers	YES (NO)
36. I like spelling	(YES) NO
37. I like arithmetic	(YES) NO
38. I am a messy writer	(YES) NO
39. Tests are easy for me to take	(YES) NO
40. I like to sound out words	YES (NO)
41. My teacher often makes me write my work again	YES (NO)
42. I have difficulty looking up words in the dictionary	YES (NO)
43. I like to use big words when I talk	(YES) NO
44. I like telling my friends about school work	YES (NO)
45. My teacher thinks I am dumb in arithmetic	(YES) NO

46.	I like going to school	YES (NO)
47.	I like playing spelling games	(YES) NO
48.	I have difficulty thinking up good stories	YES (NO)
49.	My spelling is always right	YES (NO)
50.	Saying new words is hard for me	YES (NO)
51.	I am unhappy with how I do arithmetic	(YES) NO
52.	I am a smart kid	(YES) NO
53.	I have difficulty doing what my teacher says	YES (NO)
54.	I find spelling hard	YES (NO)
55.	I usually get my arithmetic right	YES (NO)
56.	I find reading hard	YES (NO)
57.	I am unhappy with my printing	YES (NO)
58.	I am a good reader	(YES) NO
59.	I am slow at spelling	YES (NO)
60.	I am a slow reader	YES (NO)
61.	In school I find new things difficult to learn	YES (NO)
62.	I usually spell words right	(YES) NO
63.	My teacher thinks I am good at printing	YES (NO)
64.	All new words are hard for me to understand	YES (NO)
65.	I have trouble telling others what I mean	YES (NO)
66.	I am good at arithmetic	YES (NO)
67.	I like to tell stories in class	(YES) NO
68.	I feel I often say the wrong things	(YES) NO
69.	I find multiplication fun	YES (NO)
70.	I always get everything in arithmetic right	YES (NO)

Appendix B

Holistic Marking Scheme

Holistic Marking Scheme

Grade Seven (L.D.)

Mark	Comments
1.	• unable to comprehend • lacks content
2.	• the student is able to put a few words together • several different ideas may be present but there is a lack of continuity • there is a minimal amount of effort • stories within stories may exist but are unrelated
3.	• the writing is beginning to show story structure • the student shows some development of ideas • the student may not use some vocabulary appropriately or very pedestrian vocabulary (e.g., ok, good, fun) • the events in the story may be unrelated, disjointed or do not follow sequential action • there is confusion when the student attempts to hold onto distinction of roles
4.	• the student displays some logical thinking skills • there is a better organized storyline • the student attempts to use descriptive vocabulary • the student has demonstrated some creativity • parts of the story may seem unclear • the storyline, characters or events may be borrowed from TV or books • the story may have a "tacked on" ending or lacks it altogether • the story action may be unbelievable or isolated from the rest of the story
5.	• an interesting and original story • the writing displays good imagination • the writing may be informative • the student may experiment with phrasing and a variety of sentence structures • the student writing is explicit and organized • the story may have an original or humorous ending • the student has a good sense of story structure • the student is struggling with reporting dialogue • the student is developing a sense of audience • there is a distinct ending to the story

6.

- the student is able to refine own work
- the writing is concise and clear
- the student may use writing to explore ideas from various points of view
- the student is able to express more abstract notions
- the student has an excellent sense of story
- the student is able to use sophisticated vocabulary
- the student is able to use good descriptive words
- the student has a good sense of audience
- the writing has a purpose
- the storyline and characters are kept in focus
- the story action is credible; unbelievable events are explained and related
- the writer may experiment with puns, characterisation and situation
- the student is moving from a more subjective to a more objective point of view

7.

- there is a more complex and sophisticated story theme
- the student may show an appreciation for double meanings, metaphors, political and social satire
- the student is beginning to use dialogue appropriately
- there is a well developed, well explained and well organized story schema